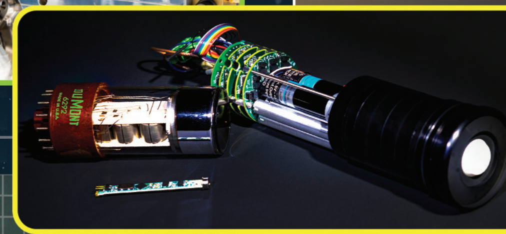
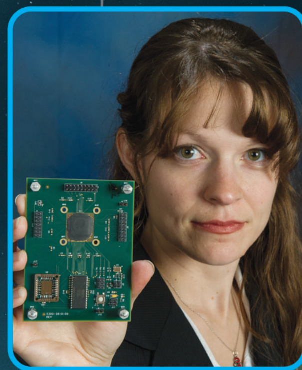
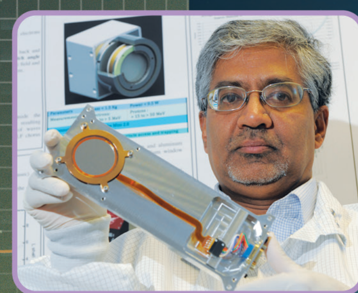
National Aeronautics and Space Administration





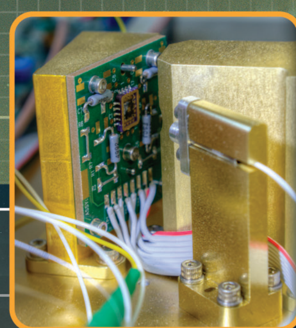


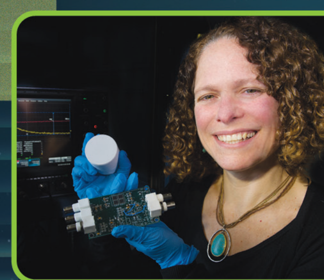
2014 R&D Achievements

Goddard Technology Development: From Scattershot to Strategic

A Report from the Goddard Office of the Chief Technologist

Goddard Space Flight Center
Greenbelt, Maryland





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2014

2014 R&D Achievements

A Report from the Goddard Office of the Chief Technologist

Peter Hughes
Chief Technologist

Chapter One

Message from the Chief Technologist:

From Scattershot to Strategic: The Power of Focus to Enable Science

Technological research and development has improved significantly over the past decade. When we published our first issue of *Goddard TechTrends* (subsequently renamed *CuttingEdge*), we considered our technology investments innovative and forward reaching, as evidenced by the infusion of some into new instruments and missions. In hindsight, however, while our funded technologies were innovative, the process by which we used to select them was scattershot, unfocused. It lacked a clearly defined, integrated process for giving priority to and selecting advanced technologies.

Hindsight is 20/20.

What changed?

Goddard established focused lines-of-business (LOBs) managed by science or specialty experts, a new business development lead, a lead technologist, and other discipline specialists responsible for identifying critical future capabilities and technologies and determining whether they could realistically attract follow-on R&D funding and interest from mission and instrument developers. We communicated our "strategic thinking" across Goddard's science and technology communities — not just to a select few decision makers — clarifying strategic priorities and identifying areas where we needed to nurture innovation. In addition to communicating our strategic direction to our scientists, engineers, and innovators, we gave them clear direction and feedback.

Today, Goddard's strategic investment portfolio and processes are highly effective. They are strategic, highly scrutinized, and currently managed along eight LOBs (see page 4 for description) designed to enable science — Goddard's raison d être. While it is true that our technology-development program always has produced innovative capabilities, the more disciplined management approach clearly took our program to a new level. Our return on investment is valued at multiple times the initial investment.

The accomplishments we highlight in this year's report are a testament to this.

We are winning follow-on R&D funding and flight missions, representing hundreds of thousands of dollars in new business. One mission stands out in particular. In FY14, NASA selected the Global Ecosystem Dynamics Investigation (GEDI) as its next Earth Venture mission. We were particularly proud of this win. Our program helped advance the laser instrument that will provide a unique three-dimensional view of Earth's forests — a much-needed measurement capability that should benefit Earth scientists for years to come.

Kudos also goes to scientist Matt McGill, the FY14 IRAD Innovator of the Year. His latest success, the deployment of the Cloud-Aerosol-Transport System to the International Space Station, followed years of consistently building technologically advanced Earth-observing instruments on budget and on time.

These are just two examples.

In the areas we have targeted, our people are winning flight opportunities on CubeSats and the International Space Station. They are demonstrating new measurement approaches and advancing new materials. They are collaborating with others to advance their concepts. They are applying for and receiving patents, an indicator of the technologies' innovation.

In closing, we are delighted that our program has supported the Goddard technology-development community in the areas that the center has deemed strategically important. We are delighted that we are playing a role in assuring Goddard's leadership in key disciplines. That is the power of focus. It keeps our eyes on the prize.

Peter Hughes
Chief Technologist
Goddard Space Flight Center

Chapter Two

The Cornerstone of Success:

Aligning Investments to Goddard's Strategic Priorities

FY14 proved to be an exceptionally productive year for Goddard technologists across all disciplines. In addition to winning an Earth Venture award — attributable to past R&D investments — our technologists continued to secure impressive levels of follow-on funding that more than compensated our initial investment in their technologies (see page 9 for details).

We believe the secret to our R&D success for Goddard's Internal Research and Development (IRAD) program and Center Innovation Fund (CIF) activities is our methodology — the focus and discipline we employ to identify investment priorities, unmet needs, and target opportunities. Because our R&D activities are driven by science applications, our investment approach is more focused and successful.

Under Goddard's IRAD program, for example, we fund only those efforts that map to one or more of Goddard's strategic lines of business. In addition, we adhere to strict selection standards and require principal investigators to compete for their awards. For NASA's Center Innovation Fund (CIF), we award research dollars only to proposals that demonstrate technical merit, feasibility, relevance, and value to NASA. All are highly innovative, crosscutting, and considered early stage in their development. Many also leverage partner resources, as well as potentially contribute significantly to national needs.

Lines of Business: At A Glance

Astrophysics
Focuses on missions and technologies enabling the study of galaxies, stars, and planetary systems beyond our own solar system.

Communication and Navigation
Supports systems and technologies needed for responsive communications and navigation.

Crosscutting Technology and Capabilities
Addresses capabilities applicable to more than one strategic line of business, everything from nano-materials and electronics to detectors and system architectures.

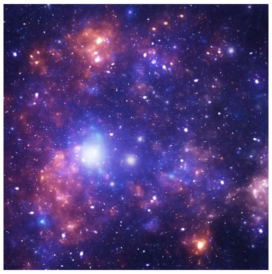
Earth Science
Supports technologies and advanced science instruments needed to observe and understand changes in Earth's natural systems and processes, including climate, severe weather, the atmosphere, the oceans, sea ice and glaciers, and the land surface.

Heliophysics
Conducts research on the sun, its extended solar-system environment (the heliosphere), and interactions of Earth, other planets, small bodies, and interstellar gas within the heliosphere.

Human Exploration and Operations
Supports infusion of science and enabling capabilities and technologies into human exploration.

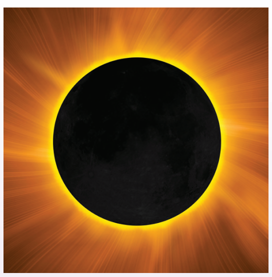
Planetary and Lunar Science
Supports technologies to explore the solar system, particularly instruments for landers and orbiting spacecraft.

Suborbital Platforms and Range Services
Supports systems typically used to place payloads into suborbital attitude, including sounding rockets, balloons, and manned and unmanned aircraft. In recent years, the LOB has expanded to include CubeSat capabilities. Range services include assets for conducting, launching, and operating missions.



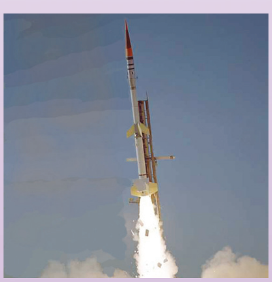
Astrophysics

Earth Science



Heliophysics

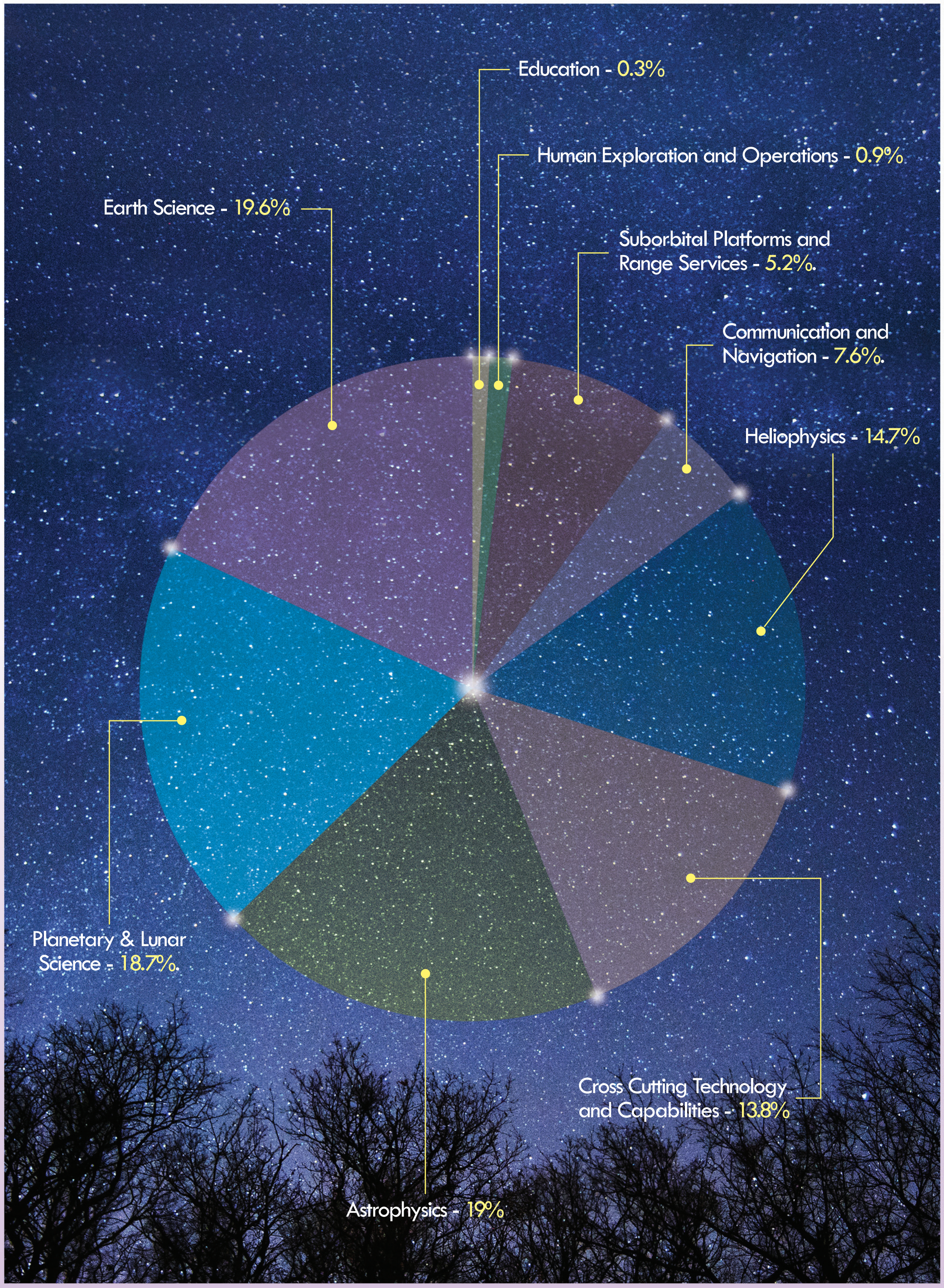
Human Exploration



Suborbital

Awards in FY '14

In FY14, we supported scores of IRAD and a dozen CIF proposals. The charts show the breakdown of those investments. Earth Science and Astrophysics received the largest portion of those R&D funds.

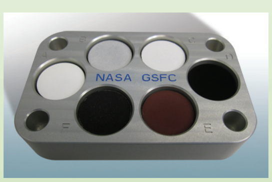


"This is the first time we've done highly accurate, high-resolution mapping to measure forest biomass from space. This wouldn't have been possible for us without support from Goddard's R&D programs over the years. This is a homegrown instrument and a homegrown technique."

— Bryan Blair, GEDI Instrument Developer

Nearly 20 years ago, IRAD Principal Investigator Bryan Blair began developing his "homegrown" laser instrument to gather data about the role of forests in carbon storage. That technology now will fly on NASA's new Global Ecosystem Dynamics Investigation (GEDI) mission.

(Photo Credit: Bill Hrybyk/NASA)



A new carbon-nanotube coating is one of several materials being tested on the International Space Station as part of the Materials Coating Experiment. The super-black material occupies the "D" slot on the sample tray.

(Photo Credit: Bill Squicciarini/NASA)

Chapter Three

The Year's Notable Achievements

The ultimate and most tangible measure of success is whether Goddard-developed technologies are chosen for inclusion in new mission or instrument opportunities. Another is whether the technology receives follow-on funding from external sources to continue its maturation or if other instrument developers infuse an R&D-funded technology into their own concepts.

As mentioned in other sections of this report, securing opportunities on CubeSats, the International Space Station, and other platforms has become one of our top priorities, as has miniaturization and new materials development. A greater share of our R&D resources are being invested in technologies that will enable small-satellite missions or reduce the size and cost of instrument and spacecraft components and systems.

This chapter details some of those accomplishments as well as others that demonstrate success, particularly in the areas of flight hardware deliveries, patent filings, and the development of enhanced capabilities to advance other cutting-edge technologies.

New Missions, Flight Opportunities, Demonstrations, and Technology Infusion

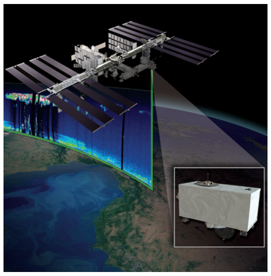
The crowning achievement of any technology program is an investment that leads to the award of a new spaceflight mission or instrument opportunity. In FY14, principal investigators won new missions and flight opportunities or demonstrated new technologies on NASA high-altitude aircraft, the International Space Station, and CubeSats.

Global Ecosystem Dynamics Investigation (GEDI) Mission

From a purely financial point of view, NASA's selection of GEDI as its next Earth Venture mission represented the center's greatest R&D success. The mission, valued at $94 million and managed by University of Maryland professor Ralph Dubayah, culminated nearly 20 years of R&D into a laser-based instrument that will allow the mission to gather unique 3D views of Earth's forests — long-needed data that will fill in details about the role of forests in the carbon cycle. GEDI, which will gather its measurements from the International Space Station, is able to perform this science because of the lidar technology advanced by Deputy Principal Investigator Bryan Blair, who drew heavily from another instrument he developed, Goddard's Land, Vegetation and Ice Sensor (LVIS). **(Investment Area: Earth Science)**

Nanotube Coating

In 2014, an emerging super-black carbon-nanotube coating ideal for suppressing stray light was delivered to the International Space Station for testing. During its one-year stay, the experiment will be exposed to harsh radiation and other elements. Knowing whether the coating can withstand the extreme environmental conditions will help further qualify the technology for potential use on space-based instruments. **(Investment Area: Crosscutting Technologies and Capabilities)**



This artist's rendering shows the data swath the Cloud-Aerosol-Transport System will follow when gathering aerosol data from its berth aboard the International Space Station.

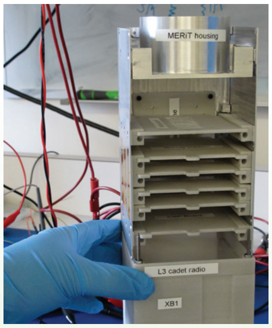
(Photo Credit: NASA)

Cloud-Aerosol-Transport System (CATS)

CATS, a pathfinder mission that will measure the character and worldwide distribution of the tiny particles that make up haze, dust, air pollutants, and smoke, was readied for launch in FY14 and delivered to the International Space Station in January 2015. From its berth on the Japanese Experiment Module, CATS will demonstrate for the first time three-wavelength active optical (lidar) remote sensing for measuring aerosols. Just as important, it showcases how lower-cost spaceborne experiments can take advantage of existing platforms — the International Space Station — thus paving the way for less costly experiments on smaller missions, with potentially more rapid access to space. **(Investment Area: Earth Science)**

Three New CubeSat Missions

NASA's Science Mission Directorate (SMD) chose a Goddard team to build IceCube, also known as Earth-1. Led by Principal Investigator Dong Wu, the team also received $4.3 million to demonstrate and validate a new 874-gigahertz submillimeter-wave receiver that could help advance scientists' understanding of ice clouds and their role in climate change. **(Investment Area: Earth Science)**



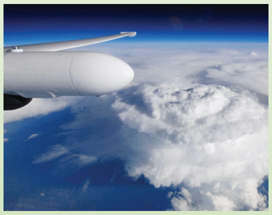
This image shows an instrument after which a new CubeSat mission, CubeSat Mission to Study Solar Particles over the Earth's Poles, will be modeled.

(Photo Credit: NASA)

Under the same solicitation, SMD also selected five Heliophysics-related missions, two involving Goddard scientists who will serve as co-investigators responsible primarily for data analysis and instrument design. Co-Investigator Eric Christian is serving as the Goddard lead on the CubeSat Mission to Study Solar Particles over the Earth's Poles, led by the Southwest Research Institute, and scientist Phil Chamberlin will analyze data collected by the Miniature X-ray Solar Spectrometer, a mission led by the University of Colorado. All will fly on three-unit or 3-U CubeSats, which are comprised of individual units each about four inches on a side. Each satellite will weigh about three pounds. **(Investment Area: Heliophysics)**

New Radar Systems Debut in Field Campaign

Goddard's High Altitude Radar group carried out the Integrated Precipitation and Hydrology Experiment in FY14 to demonstrate three new radar systems developed in part with IRAD funding. The campaign validated data for the Global Precipitation Measurement (GPM) mission and tested data-processing algorithms made by the GPM Core Observatory, launched in February 2014. The campaign, carried out from one of NASA's research aircraft, took place in the southern Appalachians specifically to measure rain in difficult-to-forecast mountain regions.
(Investment Area: Earth Science)



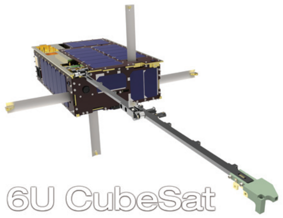
This image shows severe thunderstorms over South Carolina, as observed from NASA's ER-2 aircraft flying at 65,000 feet during the Integrated Precipitation and Hydrology Experiment.

(Photo Credit: NASA)

ASIC Infused into Three CubeSat Missions

Principal Investigator George Suarez, who designed, fabricated, and tested a 10-bit radiation-hardened, compact, four-channel digital-to-analog converter, carried out additional radiation testing in FY 14 to increase the component's technology-readiness level and encourage rapid infusion into an instrument. He succeeded. The new ASIC was incorporated into three Heliophysics-related CubeSat instruments and Sandia National Laboratories is interested in potentially using the technology. **(Investment Area: Heliophysics)**

"We're definitely leveraging lessons we learned… IRAD certainly helped, and, in fact, I think the work we did is one of the main reasons we won this mission."
— Eric Christian, Scientist



A Goddard team has designed a new-fangled 6-U CubeSat and plans to complete its construction and integration by February 2015 for a possible deployment from the International Space Station.

(Photo Credit: Luis Santos)

Eftyhia Zesta and Todd Bonalsky pose with a gimbal table they designed to test CubeSat-compatible magnetometer systems at the Goddard Magnetic Test Facility.

(Photo Credit: Bill Hrybyk/NASA)

The team assembling the ion/mass spectrometer that will fly on both Dellingr and a National Science Foundation-funded mission.

(Photo Credit: Marcello Rodriguez)

Compact Formaldehyde Fluorescence Instrument

Principal Investigator Thomas Hanisco, who has developed a non-resonant laser-induced fluorescence technique using an off-the-shelf industrial laser, will adapt the instrument to gather formaldehyde measurements from high-altitude aircraft, including the ER-2 and Global Hawk. In addition, Hanisco is working with the Ames Research Center to fly the instrument on the Atlas Jet Atmospheric eXperiment, designed to validate the Orbiting Carbon Observatory-2.

Hanisco, meanwhile, is applying similar techniques to gather hydroxide measurements and used his FY14 IRAD to develop a prototype pulsed tunable fiber laser for use on a future aircraft-borne instrument. **(Investment Area: Earth Science)**

CubeSats, Smallsats, and Miniaturization

Once a niche technology popular almost exclusively with the university community, CubeSats, small satellites, and other more diminutive platforms have increasingly become more popular among NASA scientists interested in obtaining faster and potentially less-expensive access to space. Goddard has increased its investments in advancing CubeSat capabilities, as evidenced by the successes described in this section.

New Dellingr CubeSat: A Path to Compelling Science

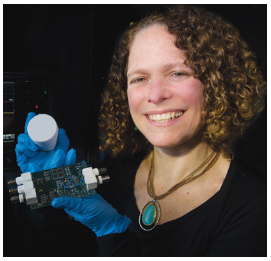
A small, dedicated Goddard team gave itself just one year to develop, test, and integrate a new-fangled CubeSat that could reliably and easily accommodate NASA-class science investigations and technology demonstrations at a lower cost. The team is on track to meet its self-imposed deadline. The team began environmental testing of a six-unit or 6-U CubeSat in late December 2014, and plans to deliver the new CubeSat to Cape Canaveral where it then will be readied for launch to the International Space Station for deployment perhaps as early as January 2016.
(Investment Area: Crosscutting Technologies and Capabilities)

Dellingr Payloads

The Dellingr six-unit CubeSat, which is taking its developers just one year to design, build, and integrate will not be the only potentially groundbreaking capability for NASA. Its Heliophysics payloads also are expected to significantly advance science on tiny platforms. Making Dellingr's maiden journey perhaps as early as January 2016 are two different magnetometer systems and a miniaturized ion/mass spectrometer — all three developed with IRAD support and all three offering scientists never-before-offered capabilities. **(Investment Area: Heliophysics)**

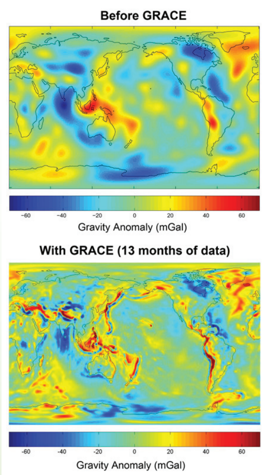
Ion/Mass Spectrometer

Instrument Principal Investigator Nick Paschalidis, who is developing Dellingr's Ion/Mass Spectrometer, delivered a version of the same instrument for the National Science Foundation-funded Exo mission, managed by the California Polytechnic State University. The instrument will measure the composition and density of various ions and neutral elements in Earth's lower exosphere and upper ionosphere. Photo left, from left to right: Sarah Jones, Dennis Chornay, Nick Paschalidis, Ed Sittler, Tim Cameron (seated, right), and Marcello Rodriguez (seated, center).
(Investment Area: Heliophysics)

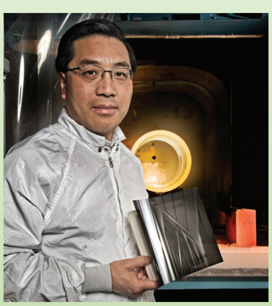


Goddard scientist Georgia de Nolfo holds components that make up her miniature neutron spectrometer, which she developed for a CubeSat mission sponsored by the Air Force University Nanosat Program.

(Photo Credit: Bill Hrybyk/NASA)



An emerging atom optics-based gradiometer could succeed NASA's GRACE mission.



Principal Investigator Will Zhang is using PCOS funding to advance techniques for fabricating X-ray optics. He is shown holding one of his X-ray mirrors.

(Photo Credit: Chris Gunn)

Neutron Spectrometer

Another Goddard heliophysicist, Georgia de Nolfo, also delivered her miniature neutron spectrometer for inner radiation belt studies in 2014. Supported by the IRAD program, the instrument was developed under the auspices of the Air Force University Nanosat Program. Although a launch is not guaranteed, it could fly in 2015 or 2016 aboard a 6-U CubeSat built by New Mexico State University. **(Investment Area: Heliophysics)**

Follow-On Funding to Advance Technology-Readiness Levels

The IRAD and CIF programs are not meant to provide cradle-to-grave support. Therefore, a key success metric is whether principal investigators succeed in securing follow-on funding to further advance their technologies. In FY14, these funding sources came from NASA's Instrument Incubator Program (IIP), Strategic Astrophysics Technology (SAT) program, Planetary Instrument Concepts for the Advancement of Solar System Observations (PICASSO), Fundamental Mars, Heliophysics Technology and Instrument Development for Science (H-TIDeS), Science Mission Directorate, Wide-Field Infrared Telescope (WFIRST), Physics of the Cosmos (PCOS), Earth Science Technology Office (ESTO) Advanced Component Technology (ACT), Global Precipitation Measurement (GPM) mission, and Astrophysics Research and Analysis (APRA), among others.

Atom Optics for Mapping Earth's Gravitational Field

Principal Investigator Babak Saif received $5 million in ESTO IIP funding to build an atom optics-based gradiometer that would map Earth's gravitational field, which appears lumpy due to the uneven distribution of mass. The instrument could potentially succeed NASA's Gravity Recovery and Climate Experiment. Saif's goal is to advance the gradiometer from its current technology-readiness level of three to five. **(Investment Area: Earth Science)**

New Cloud/Precipitation Radar

Principal Investigator Lihua Li and his industry partner, Northrop Grumman Electronic Systems, received $4.5 million in ESTO IIP funding to develop cloud/precipitation radar phase array transmit/receiver modules. A small fraction of the funding will be used for in-house electronics board and algorithm development. **(Investment Area: Earth Science)**

Extreme UV Normal Incidence Spectrograph

Principal Investigator Adrian Daw served as the deputy of a FY13 Task Group called the "Multi-Discipline, Multi-Mission Working Group Approach to Calibration," which, along with the IRAD program, helped him advance extreme-ultraviolet calibration techniques. In FY14, he won $1.6 million in H-TIDeS funding to modify and launch the Extreme UV Normal Incidence Spectrograph on a sounding-rocket mission. **(Investment Area: Heliophysics)**

Advanced X-ray Optics

Principal Investigator Will Zhang received $3.9 million in PCOS funding to continue advancing new techniques for fabricating X-ray optics. With this technique, Zhang is showing that he can construct these highly specialized mirrors using flat sheets of glass that have been placed on a rounded mold, and then heated. He also is investigating fabricating the mirrors with blocks of mono-crystalline silicon. **(Investment Area: Astrophysics)**

Principal Investigator Haris Riris (left) and Stewart Wu prepare a prototype of the Methane Sounder (the mirror is an alignment tool) before demonstrating it aboard NASA's DC-8 research aircraft in 2011. Another flight is scheduled for later this year.

(Photo Credit: Emily Schaller)

Methane Sounder Demonstration

With $1.2 million in recently awarded ESTO IIP and ACT funding, Goddard scientist Haris Riris and his team will continue advancing the Methane Sounder. The next-generation instrument will be able to provide remotely collected, high-resolution, highly accurate, around-the-clock global methane measurements should it ultimately fly as a spaceborne instrument. Haris and his team are using the new funding to further improve the prototype instrument and then test it during a NASA DC-8 aircraft campaign later in 2015. **(Investment Area: Earth Science)**

A Contribution to the European Space Agency's (ESA) eLISA Mission

The gravitational wave space mission, eLISA, which will be proposed for the European Space Agency's L2 launch opportunity, may include a NASA contribution. Principal Investigator Jordan Camp has received $1 million in SAT funding to demonstrate an eLISA laser system by 2015, allowing maximum flexibility to implement the mission, which is expected to reveal the physics and astronomy associated with the merger of massive black-hole systems. The backbone of eLISA is a highly stable laser using about 1.2 watts of power, enabling the picometer interferometry necessary to record the passage of a gravitational wave. **(Investment Area: Astrophysics)**

Methane Measurements of Melting Permafrost

Emily Wilson, who has developed a novel suitcase-size instrument to measure column carbon dioxide and methane, is taking her recently patented instrument on the road in June 2015 to comprehensively measure emissions of these important greenhouse gases from Alaska's melting permafrost. To carry out the field campaign, Wilson and her team received $980,000 in ROSES Interdisciplinary Science funding to measure the emissions with her miniaturized Laser Heterodyne Radiometer from three sites — each representing a different type of permafrost. **(Investment Area: Earth Science)**

Goddard engineer Lance Oh is working with Principal Investigator Harvey Moseley to develop the next-generation shutter arrays, which are as functional as magnetically actuated arrays.

(Photo Credit: Bill Hrybyk/NASA)

Next-Generation Microshutter Array

Goddard technologists have hurdled a number of significant technological challenges in their quest to improve an already revolutionary observing technology originally created for the James Webb Space Telescope. The team, led by Principal Investigator Harvey Moseley, received $915,000 in three-year APRA funding to further advance the technology, which has demonstrated that electrostatically actuated microshutter arrays — also known as next-generation arrays — are as functional as magnetically actuated arrays, making them a highly attractive capability for potential Explorer-class missions designed to perform multi-object observations. **(Investment Area: Astrophysics)**

High-Resolution X-ray Sensors

Goddard Principal Investigator Jay Chervenak and his partner, University of Maryland researcher Simon Bandler, received a three-year, $600,000 HTIDeS award to further enhance high-resolution X-ray sensors for point-source applications. The effort will extend the technology to higher count rates for high-flux sources, like the sun. The team also will develop ultra-fine wiring to accommodate a closely packaged focal plane. **(Investment Area: Heliophysics)**

Gamma-Ray Polarimeter

Completing the development of the Three-Dimensional Track Imager — also known as 3-DTI — and building a 50x50x100-centimeter prototype of a medium-energy gamma-ray polarimeter are the goals under a $550,000 APRA awarded to Principal Investigator Stan Hunter. Hunter will take the prototype to an accelerator and test it using 100-percent polarized gamma rays.
(Investment Area: Astrophysics)

Radio Interference Mitigation

Radio interference is a challenge that Principal Investigator Mark Wong is attempting to overcome with $540,000 in GPM and ACT funding. Wong is researching and developing algorithms and hardware that mitigate radio-frequency interference in future high-frequency radiometer missions.
(Investment Area: Earth Science)

Principal Investigator Jen Eignenbrode, a past "IRAD Innovator of the Year," won 2013 Mars Fundamental funding to analyze irradiated organics in martian mineral analogs.

(Photo Credit: Chris Gunn/NASA)

Analysis of Martian Analogs

Principal Investigator Jen Eigenbrode, a past "IRAD Innovator of the Year," won $111,000 in 2013 Mars Fundamental funding to carry out organic analyses of irradiated organics in martian mineral analogs. She is using the same approach she developed under past IRAD awards.
(Investment Area: Planetary and Lunar Science)

MARS Lidar for Global Climate Measurements

Principal Investigator Jim Abshire received $780,000 in PICASSO funding to develop and test a lab version of a lidar designed to measure from Mars orbit the planet's vertically resolved wind field and dust distribution. The investigation team also includes Michael D. Smith, Haris Riris, Xiaoli Sun, Bruce Gentry, Anthony Yu, and Graham Allan (Sigma Space). The win was directly related to an IRAD that Abshire received in FY13. **(Investment Area: Planetary and Lunar Science)**

X-Ray Spectroscopy

Under a $227,000 PICASSO award, Principal Investigator Lucy Lim is developing a miniature electron probe. The instrument will significantly advance scientists' ability to remotely determine the elements contained in planetary, asteroidal, and cometary material — data that will provide clues about the processes by which rocks, soils, and ices were formed and altered, thus recording past stages in the evolution of the solar system. **(Investment Area: Planetary and Lunar Science)**

Goddard technologists Mae Huang and Victor Marrero-Fontanez have collaborated to test and verify components of a prototype end-to-end Ka-band space communications system. In this photo, Huang is holding a test board upon which her Ka-band/microwave design is mounted and bonded.

(Photo Credit: Bill Hyrbyk/NASA)

Ka-Band Space Communications

Under two different research and development efforts, Principal Investigators Mae Huang and Victor Marrero-Fontanez tested and verified components of a prototype end-to-end Ka-band space communications system, which promises significantly higher data rates — a whopping 2.6 gigabits of data per second — over more traditional S-band systems. Huang, who received $80,000 from a team developing the proposed Wide-Field Infrared Survey Telescope (WFIRST), will deliver to the WFIRST team a Ka-band transmitter for testing. **(Communications and Navigation)**

Fine-Pixel CdTe Detectors

Principal Investigator Steven Christe won $1.2 million in APRA funding — of which $415,000 will go directly to Goddard — to further enhance an application-specific integrated circuit that will be combined with a CdTe detector for hard X-ray telescopes. Under the award, Christe will develop detector assemblies that meet astrophysics requirements; however, the technology also is applicable to the SuperHERO balloon mission, which studies particle acceleration in solar flares.
(Investment Area: Astrophysics and Heliophysics)

Strategic Collaborations

Research and development can be expensive, often taking years to produce meaningful results. That is why Goddard innovators are encouraged to seek partnerships to advance particularly viable new ideas. Ultimately, these strategic partnerships can lead to the infusion of cutting-edge technologies into new missions and commercial products.

Goddard Principal Investigator Antti Pulkkinen is working with a handful of U.S. power companies in a first-of-its-kind weather project that, in effect, creates extremely large antennas for space physical and geophysical remote sensing.

(Photo Credit: Bill Hyrbyk/NASA)

Teaming with U.S. Utilities to Create First-of-its-Kind Antenna

A Goddard team is using the nation's high-voltage power transmission lines to measure a phenomenon that has caused widespread power outages in the past — a first-of-its-kind space-weather project that, in effect, creates extremely large antennas for space physical and geophysical remote imaging. Scientist Antti Pulkkinen and his team have installed scientific substations beneath these lines to measure in real-time geomagnetically induced currents, which typically occur one-to-three days after the sun unleashes a coronal mass ejection, which can slam into Earth's near-space atmosphere and cause the electric currents within the magnetosphere to fluctuate. Since starting the project in FY14 with Dominion Virginia Power, the team has established partnerships with other power companies, including American Electric Power, PJM Interconnection, NextEra, and Southern Company.
(Investment Area: Heliophysics)

Goddard Teams with APL to Develop Neutral New Camera

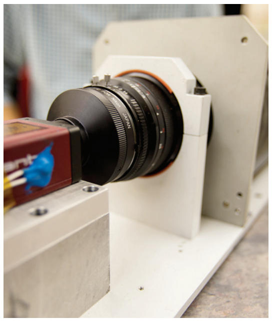
Goddard Principal Investigator Nick Paschalidis, a prolific instrument developer (see page 8), has teamed with the Applied Physics Laboratory to develop a next-generation instrument in preparation for future mission calls. Paschalidis also is collaborating with the European Space Agency for similar opportunities. **(Investment Area: Heliophysics)**

Critical Support Capabilities and Materials

Some technologies are not meant to provide scientific data; their sole purpose is to provide technologists and others with capabilities that assist them in their quest to develop advanced science instruments or to interpret data needed by the public.

Wallops Arc-Second Pointer (WASP)

The Wallops Arc Second Pointer (WASP), which can point balloon-borne scientific instruments at targets with sub arc-second accuracy and stability, flew two missions in 2014, along with a new star tracker designed to locate points of interest, or stars, during daylight hours. A precision attitude sensor, like the prototype star tracker, would extend scientific operations, giving scientists far more data. Both WASP and the star tracker are designed to be highly flexible, standardized, and capable of supporting many different scientific investigations.
(Investment Area: Suborbital Platforms and Range Services)



Wallops engineer Scott Heatwole and his team are developing a precision attitude sensor or star tracker that would be able to locate points of reference, or stars, during daylight hours. Heatwole specifically developed the technology for the Wallops Arc Second Pointer.

(Photo Credit: Patrick Black/NASA)

Hilbert-Huang Transform for 2D (HHT2)

Scientists will be able to process and recover radiometer-gathered data contaminated by radio frequency interference (RFI). Principal Investigator Semion Kizhner said that his HHT2 delivers RFI-free science and recovers 15 percent of previously lost data. Scientists also can apply the HHT2 to heritage data. (Investment Area: Earth Science)

Semion Kizhner (right) has developed the Hilbert-Huang Transform for 2D that delivers RFI-free science data.

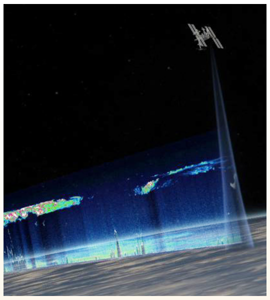
(Photo Credit: Debora McCallum/NASA

Cis-Lunar/Earth-Moon Libration Orbit Reference and Web Application

NASA has recently invested a great deal of time determining how to operate missions in Earth-Moon (cis-lunar) regions. In FY14, Principal Investigator Dave Folta developed an orbit reference and Web application that could result in more fully informed decisions regarding robotic and habitat missions in cis-lunar space. This Goddard-developed reference, which until now did not exist, will be available as a searchable Web-based application to explore design options and generate essential trajectory data. Folta worked with Purdue University to create the capability.
(Investment Area: Planetary and Lunar Science)

"In all cases, the group built these important climate-change instruments with a small team, a streamlined process, and a build-to-cost mentality… The team's success is a testament to its can-do spirit and vision, and demonstrates how NASA innovators can be so effective."

— Goddard Chief Technologist, Peter Hughes



This artist's rendition shows the technique that the Cloud-Aerosol-Transport System instrument employs to gather aerosol and pollution data from its berth on the International Space Station.

Goddard leaders pose with the FY14 IRAD Innovator of the Year team. From left to right: Peter Hughes, Matt McGill, Andrew Kupchok, Stan Scott, John Yorks, Colleen Hartman, and Piers Sellers.

(Photo Credit: Bill Hrybyk/NASA)

Chapter Four

A Year of Accolades for FY14 IRAD Innovator of the Year, Matt McGill and Team

Goddard scientist Matt McGill, who has earned a reputation over the years for consistently delivering technologically advanced Earth-observing instruments on budget and on time, won the FY14 IRAD Innovator of the Year award, bestowed annually on those who achieve significant results that benefit NASA and others in the communities they serve.

McGill and his team, including Andrew Kupchok, Stan Scott, and John Yorks, received the Office of the Chief Technologist's annual award at the FY14 Poster Session due to their success designing and building three different instruments vital to climate-change studies and pursuing new platforms from which to fly the innovative concepts — a notable achievement given that all three were designed, built, and delivered in just a few years' time.

"In all cases, the group built these important climate-change instruments with a small team, a streamlined process, and a build-to-cost mentality," said Goddard Chief Technologist Peter Hughes. "He and his team also leveraged multiple NASA technology resources, including the SBIR (Small Business Innovation Research) and ESTO (Earth Science Technology Office) programs. The team's success is a testament to its can-do spirit and vision, and demonstrates how NASA innovators can be so effective."

For example, the Cloud-Aerosol-Transport System, which NASA deployed on the International Space Station in early January 2015, is demonstrating for the first time three-wavelength active optical (lidar) remote sensing. In addition, it is showcasing how lower-cost spaceborne experiments can take advantage of existing platforms — the International Space Station — thus paving the way for less costly experiments on smaller missions, with potentially more rapid access to space.

Another instrument, the proof-of-concept Multiple Altimeter Beam Experimental Lidar — built in just one year, from concept, design, procurement, assembly, and first flight — proved that photon counting worked at high altitude and was suitable for the Ice Cloud and land Elevation Satellite-2 mission.

And long before others began considering unmanned aerial vehicles (UAVs) as potential platforms for research, McGill saw an opportunity for his already successful Cloud Physics Lidar. Until then, the instrument had flown exclusively on piloted research aircraft. With Goddard's IRAD funding, he retrofitted the "airplane" instrument so that it would be compatible with an autonomous platform and two years later, the UAV-compatible instrument debuted on the maiden flight of NASA's Global Hawk aircraft. Now, it's an important player in NASA's Hurricane and Severe Storm Sentinel mission.

Chapter Five

Technologies to Watch

Research and development is a high-risk endeavor. In some cases, the research doesn't yield the expected outcome or result. In others, the principal investigator achieves precisely what he or she set out to accomplish. Here we spotlight just a few R&D-funded efforts that are early-stage, often higher-risk technologies that could one day result in Goddard creating new opportunities and helping NASA carry out its science and exploration missions.

Astrophysics

X-ray Detector Advanced for European Athena Mission

The European Space Agency has approved a next-generation X-ray observatory. If Principal Investigator James Chervenak has his way, the mission will use detector technologies and manufacturing processes he pursued with his IRAD award — work he believes will better position Goddard's detector group for possible inclusion in the mission. As a result of his work, members of the detector fabrication team were awarded the Robert H. Goddard Team Award for the improvement of detector processes.

Fabrication of Partially Transparent Petaled Masks Using Gray-scale Lithography

Principal Investigator Ron Shiri successfully designed, fabricated, and analyzed partially transparent petaled masks using gray-scale lithography on high-energy beam-sensitive glass. The masks could be ideal for suppressing reflected light on the center of a secondary mirror in the New Space-based Gravitational-wave Observatory telescope. Shiri plans to partner with another NASA center to further advance the technology.

Balloon Experimental Twin Telescope for Infrared Interferometry (BETTI)

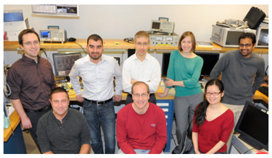
BETTI is a far-infrared interferometer designed to fly on high-altitude balloons. In many respects, the instrument is a technical pathfinder for future space-based interferometers, and as the first interferometer in "space," BETTI will serve as the foundation upon which these interferometers are built. In FY14, Principal Investigator Stephen Rinehart completed the design, fabrication, and subsystem testing of the instrument's electrical system and completed and tested the instrument's structure.

An Ideal Integrating Bolometer

Work continues on a novel detector that could enable a new class of far-infrared spectroscopic surveys. The detector, the Ideal Integrating Bolometer (IIB), is able to circumvent some of the inherent limitations in bolometers, thereby achieving dramatic improvement in sensitivity. Of the two key technologies needed for the IIB, one, the magnetic penetration thermometer, has progressed dramatically. Principal Investigator Ed Canavan now is focusing his efforts on advancing the other important technology, a micro-fabricated heat switch.

Novel Magnetically Tuned Transition-Edge Sensor for Imaging X-ray Spectroscopy

Superconducting transition-edge sensors (TESs) are the state-of-the art technology for microcalorimeter and bolometer applications across the electromagnetic spectrum. Under this research effort, led by Principal Investigator John Sadleir, the team designed, fabricated, and tested a magnetically tuned TES. Sadleir believes the results are very exciting, promising improved TES performance. A successful demonstration would be game changing in the field, maintain Goddard's competitiveness, enable new mission concepts, and provide the proof of concept necessary for follow-on technology-development funding.



A Goddard team is modernizing the Navigator GPS receiver by implementing advanced and modernized GPS signal capabilities on a combined Navigator-SpaceCube flight platform. Team members include (back row, left to right): Sam Price, Monther Hasouneh, Luke Winternitz, Jennifer Valdez, Luke Thomas; (front row, left to right): Tony Marzullo, Harry Stello, and Annie Chen.

(Photo Credit: Pat Izzo/NASA)

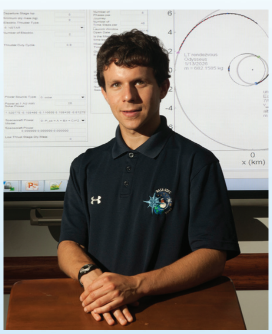
Broadband Silicon Dielectric Mirrors for Infrared Astronomy

Principal Investigator Kevin Denis began developing fabrication processes to create silicon-based mirrors, targeting, in particular, the 25-60-nanometer wavelength range for cryogenic spectroscopy. In FY14, Denis successfully scaled up the fabrication process to demonstrate an 18-millimeter diameter two-layer mirror. Silicon-based reflectors are a critical component in a variety of future missions. The team's primary goal was retiring technology risks early.

Communication and Navigation

Modernization of Navigator: NavCube

The work performed under this FY14 IRAD markedly enhanced Goddard's homegrown Navigator GPS receiver. Principal Investigator Monther Hasouneh is implementing advanced and modernized GPS signal capabilities on a combined Navigator-SpaceCube flight platform — a capability he calls Navigator-SpaceCube. He is partnering with Goddard SpaceCube developers and is planning to fly NavCube on an Air Force-sponsored experiment on the International Space Station in 2017.



Principal Investigator Jacob Englander has begun developing a high-fidelity modeling and optimization tool for low-thrust mission designs.

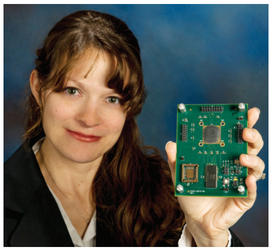
(Photo Credit: Pat Izzo/NASA)

GPS Transmit Antenna Side Lobe Characterization

Meanwhile, Principal Investigator Jennifer Valdez has collaborated with the Aerospace Corporation and the defense community to characterize the side lobes of the GPS satellite-transmit antennas. The aim is to better understand the availability of GPS signals in high-Earth orbits and improve the current state of the art in navigation performance.

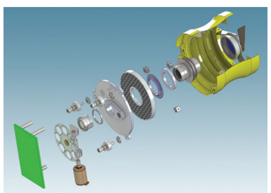
End-to-End Low-Thrust Trajectory Optimization and Analysis

In FY14, Principal Investigator Jacob Englander began developing a high-fidelity modeling and optimization tool for low-thrust mission designs — a capability that Englander says is necessary for future missions. Leveraging advances he made with a medium-fidelity tool, Englander said he implemented the high-fidelity technology into GMAT for testing.



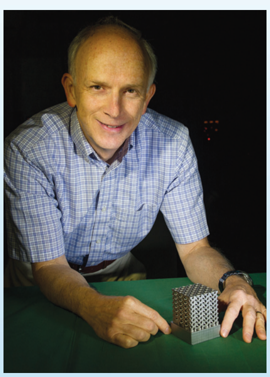
Principal Investigator Beth Paquette holds the Goddard-developed housekeeping on a chip.

(Photo Credit: Bill Hrybyk/NASA)



This is an exploded view of the CubeSat-class 50-millimeter imaging instrument that technologist Jason Budinoff is manufacturing with 3D-printed parts.

(Photo Credit: Jason Budinoff/NASA)



Principal Investigator Tim Stephenson is working with Goddard scientists to create 3D-manufactured components for instruments that would image exoplanets.

(Photo Credit: Bill Hrybyk/NASA)

Crosscutting Technologies and Capabilities

A Radiation-Hardened Multi-Channel Analog-to-Digital Converter

Principal Investigator George Suarez designed and developed a radiation-hardened analog-to-digital converter application-specific integrated circuit for miniaturized instrument electronics — an effort aimed at reducing the power, mass, and volume for highly resource-constrained instruments. Suarez plans to perform functional, performance, radiation and temperature cycling testing in FY15.

Common Customizable Instrument Electronics Packages

Principal Investigator Beth Paquette accomplished, among other things, the successful demonstration of a housekeeping system on a chip, which would combine different functions inherent in all instruments, including housekeeping, data processing, power, digitalization, and control and data handling, all into a single, miniaturized device.

Gravity Independence of Microchannel Two-Phase Flow

In collaboration with the University of Maryland, Principal Investigator Franklin Robinson has begun work on a compact, two-phase cooler that would remove heat from chip-scale systems — an effort that contributed to his being nominated for the Mechanical Systems Division's Excellence Award in 2014. The team has submitted an invention disclosure.

3D-Printed Space Cameras

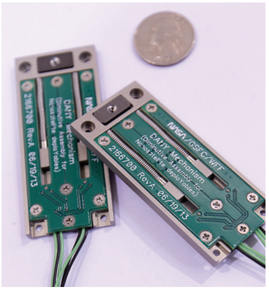
Engineer Jason Budinoff spent FY14 completing the first imaging telescopes ever assembled almost exclusively with 3D-printed parts. Under the multi-pronged project, Budinoff built a fully functional, 50-millimeter camera whose outer tube, baffles, and optical mounts were all printed as a single structure and appropriately sized for a CubeSat. He also assembled a 350-millimeter dual-channel telescope and plans to experiment with printing instrument components made of Invar alloy, a material being prepared for 3D printing by another Goddard technologist, Tim Stephenson (see below).

3D Manufacturing Pursued for Astrophysics Applications

In addition to collaborating with Jason Budinoff (see above), Principal Investigator Tim Stephenson, meanwhile, is working with two Goddard scientists to create 3D-manufactured components for instruments that would image exoplanets and detect gravitational waves.

Broadband Meta-Material Anti-Reflection Coatings

Principal Investigator Ed Wollack, working with the University of Michigan, began work on a broadband low-reflectance coating, which could be used to develop sensors, optical elements, and precision components for astrophysics, planetary, and Earth-observing remote systems at microwave through terahertz wavelength bands. To create these meta-materials, the team tackled two key technical challenges: 1) Designed and characterized precision-engineered materials; and 2) Planned to explore the fabrication of high-tolerance test structures via laser cutting and chemical milling. The team plans to submit a peer-reviewed paper in 2015.



The Diminutive Assembly for Nanosatellite deploYables stows solar panels, antennas, and even sunshades on CubeSats.

(Photo Credit: Patrick Black/NASA)

Diminutive Assembly for Nanosatellite deploYables (DANY)

Engineer Luis Santos Soto, a key player in the development of the Dellingr 6-U CubeSat (see page 8), is working to secure a sounding-rocket flight to demonstrate DANY. He designed the technology to reliably deploy stowed solar panels, antennas, or even sunshades on small satellites, including CubeSats.

Precision Vapor-Deposited Coatings for Detector and Optical Coupling Applications

Under this research effort, Principal Investigator Ed Wollack developed a process for producing reproducible and stable coatings or films for transition-edge sensors, Microwave Kinetic-Inductance Detectors (MKIDs), and optics using a state-of-the art sputtering-deposition system. More specifically, the team planned to develop novel alloy films by depositing up to four different materials simultaneously on a silicon wafer. Successful infusion of these materials into space-borne detectors will enable the next generation of tools for scientific discovery.

Earth Science

Principal Investigator Stan Hooker holds his prototype instrument that would gather ocean-color data under low-light conditions.

(Photo Credit: NASA)

X-Badger System

Principal Investigator Amber Emory is poised to demonstrate the X-band Atmospheric Doppler Ground-based Radar (X-BADGER), formerly known as the ER-2 Doppler radar. The goal under her FY14 research was to incorporate a forward-pointing beam to add essential polarimetric capabilities necessary for analyzing precipitation microphysics. According to Emory, a need currently exists for 3-centimeter wavelength radars. X-BADGER fulfills that need and positions Goddard to win future ground-validation efforts for precipitation-related missions. The instrument will be field tested on the Olympic Peninsula in the Pacific Northwest during the winter months of 2015-2016.

Ocean Color Underwater Low Light Advanced Radiometer (OCULLAR)

A Goddard-led team has developed an instrument capable of observing ocean color during normal sunlight conditions and under moonlight — a first-ever capability that will allow scientists to monitor the health and chemistry of the planet's oceans literally around the clock. The prototype OCULLAR has shown in field testing that it can measure ocean color under low-light conditions across multiple wavelength bands. Principal Investigator Stan Hooker now is attempting to commercialize the technology.

Lidar Earth Venture Ecosystem Explorer (LEaVEs)

Principal Investigator Anthony Yu has big plans for a laser altimeter that would be equipped with more power-efficient lasers and photon-counting detectors — in other words, technologies critical to realizing NASA's proposed Lidar Surface Topography (LIST) mission. In FY14, Yu advanced several techniques that he would like to apply to a precursor instrument, called LEaVEs. Envisioned as an International Space Station payload, LEaVEs would be equipped with 25 laser beams that would help the instrument generate detailed topographical and vegetation maps needed to forecast and respond to natural hazards.

Goddard scientist Emily Wilson poses here with the exterior shell of a potential CubeSat. It would carry a version of her miniaturized Laser Heterodyne Radiometer — an instrument for which she received a patent in 2014.

(Photo Credit: Bill Hrybyk/NASA)

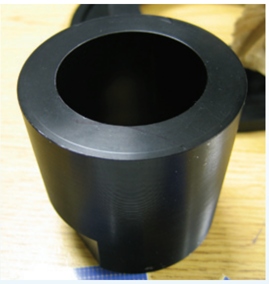
Carbon Observing Worldwide Satellite (COWSat)

Principal Investigator Emily Wilson, who will use her IRAD-funded instrument — the mini Laser Heterodyne Radiometer — to measure methane emissions from melting permafrost in Alaska (see page 10), is applying the instrument to a CubeSat, which she calls COWSat. Among other technologies, COWSat may carry a new, IRAD-funded digital processor developed by Damon Bradley. The processor, advanced through an FY14 research effort, specifically was designed for CubeSat missions.

Instrumentation for Direct Validation of Regional Carbon Flux Estimates

Meanwhile, Principal Investigator Randy Kawa assembled an airborne system for directly measuring atmospheric methane and is now planning to construct an instrument system for NASA's C-23 Sherpa. The instrument, which was tested in a ground campaign in Colorado in 2014, would be used to validate data gathered by the Orbiting Carbon Observatory-2 and cement NASA as the leading U.S. institution for integrated carbon science.

Heliophysics



This image shows a close-up view of a baffle that will be coated with a new carbon-nanotube coating. The component was designed for a new solar coronagraph designed to fly on the International Space Station.

(Photo Credit: Paul Nikulla/NASA)

Solar Coronagraph and Carbon Nanotubes

Principal Investigator John Hagopian, who has pioneered the development of a new carbon-nanotube coating, applied the new technology to a complex, 3D-shaped component critical for suppressing stray light in a smaller, less-expensive solar coronagraph designed to fly on the International Space Station or as a hosted payload on a commercial satellite. In FY14, Hagopian also prepared samples of the material for testing aboard the orbiting outpost (see page 6).

Quantifying Radiation Storm Impacts on Interplanetary Missions

Solar energetic particles can harm spacecraft electronic systems. Under her FY14 IRAD, Principal Investigator Yihua Zheng developed tools capable of computing space-radiation effects on spacecraft components. The user-friendly tools, which leverage the capabilities of two different Goddard directorates, will quantitatively assess radiation hazards — information needed by mission managers to protect space assets during solar storms.

An Adaptive Langmuir Probe for CubeSats and Explorers

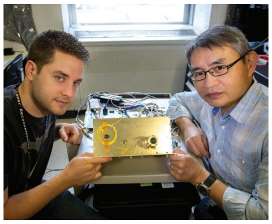
Langmuir probes provide an essential measurement of plasma diagnostics both in space and in the laboratory. By sweeping a small metal probe over a range of voltages and measuring the collected current, key information about plasma can be inferred. Though simple to operate, it is difficult integrating these devices into CubeSats. Principal Investigator Jeffrey Klenzing is attempting to mitigate those issues through the development of the adaptive Langmuir probe. In FY 14, initial testing was completed, validating a proof-of-concept device.

Human Exploration and Operations

Graphene Field Effect Transistor (FET) Radiation Sensors

Graphene is a new class of nano-materials that potentially could be used for a variety of spaceflight applications. Under this research effort, Principal Investigator Mary Li continued the development of graphene FET radiation sensors for NASA's future human spaceflight missions — particularly, as a device that crewmembers could carry to sense harmful levels of radiation. This is the first time that a research team has developed this type of sensor for space applications.

3D-Imaging Lidar



Nat Gill and Tony Yu are developing new lidar systems for satellite servicing and close approaches to asteroids. They are shown here with hardware they developed for the Goddard Reconfigurable Solid-state Scanning Lidar.

(Photo Credit: Bill Hrybyk/NASA)

Building, fixing, and refueling space-based assets or rendezvousing with a comet or asteroid will require a robotic vehicle and a super-precise, high-resolution 3D-imaging lidar that will generate real-time images needed to guide the vehicle to a target traveling at thousands of miles per hour. A team of Goddard technologists now is developing a next-generation 3D-scanning lidar — dubbed the Goddard Reconfiguable Solid-state Scanning Lidar — that could provide the imagery needed to execute these orbital dances. The current system has achieved a technology-readiness level of five.

Cryogenic Hydrogen Radiation Shield

Protecting astronauts from overdoses of radiation is critical for the future of human spaceflight. Aluminum is not an ideal material for radiation shielding — especially for lengthy, deep-space missions. That is because the size of its nucleus can contribute to the total ionizing dose that an astronaut would receive. In FY14, Principal Investigator Li Xiaoyi developed a preliminary design of a cryogenic hydrogen radiation shield, increasing its technology-readiness level from one to two. The team is now seeking additional NASA funding to pursue the technology's development.

Planetary and Lunar Science

Cryogenic Propulsion for Planetary Science Missions

Cryogenic propellants, such as liquid hydrogen and liquid oxygen, can dramatically enhance NASA's ability to explore the solar system because of their superior specific impulse capability. In FY14, Principal Investigator Shuvo Mustafi performed a design study for a cryogenically propelled planetary mission that minimizes the launched mass. He also designed a subscale demonstration that will validate the subcooling of cryogenic propellants on the launch pad.

Firing Mechanism Concept for Sample Acquisition System

Principal Investigators Caitlin Bacha and Daniel Ramspacher made good progress analyzing, designing, building, and testing a firing mechanism for the Sample Retrieving Projectile — a technology that could be used to fire any type of projectile with a mass of about 2 kg to velocities of up to 50 miles per second.

Micro-Cylindrical Ion Trap Micro-Mass Spectrometer

Principal Investigator Yun Zheng is making good progress developing a modular and flexible packaging concept for a MEMS micro-mass spectrometer. He is designing the technology so that it can be integrated into a micro-gas chromatograph, micro-vacuum chamber, and microelectronic components — all that could be deployed on a pico-satellite array or other distributed planetary-payload systems.

Multi-Planetary Electrical Environment Spectrum Analyzer

Principal Investigator Damon Bradley successfully developed and demonstrated an important technology for a highly integrated planetary radio- and digital-spectrum analyzer for use as a CubeSat payload. In FY14, he and his team developed and demonstrated a functional radio-frequency front-end electronics subsystem.

Suborbital Platforms and Range Services

Sean Semper (left), Phil Calhoun, and Neerav Shah (right) are advancing the technologies needed to create a virtual telescope that they plan to demonstrate on two CubeSats.

(Photo Credit: Bill Hrybyk/NASA)

Creating a Virtual Telescope

Although scientists have flown two spacecraft in formation, no one ever has aligned the spacecraft with a specific astronomical target and then held that configuration to make a scientific observation — creating, in effect, a single or "virtual" telescope with two distinctly different satellites. However, a Goddard team is developing CubeSat-compatible technologies that would enable such a technique. Under the plan, the two CubeSats would work in tandem to create a high-resolution solar coronagraph. With IRAD funding, Sean Semper, began developing an astrometric camera central to aligning the spacecraft.

Multi-Channel CDMA Demodulator for Small Satellites

In FY14, Principal Investigators Wing Lee and Wai Fong began designing a formation-flying backbone that would allow simultaneous crosslink communications between daughter satellites and a centralized mother satellite. Under the configuration, the daughter ship would communicate directly with the mother ship via a managed common communications link. The team has completed detailed analytical modeling and plans to pursue additional funding to further advance the concept.

CubeSat Form Factor Thermal Control Louvers

Despite the benefits of CubeSats, they do present challenges. In FY14, Principal Investigator Allison Willingham began developing a passive method to stabilize the thermal environment inside small spacecraft via miniature thermal louvers. She created a prototype design, completed structural and thermal analyses, and performed proof-of-concept and life testing. Several NASA scientists have expressed interest in the technology as a way to hold a tighter temperature range.

Small Unmanned Aerial Control Center

In FY14, Principal Investigator Bob Stancil gathered requirements, designed, developed, and integrated a small Unmanned Aerial System Control Center that would allow the Wallops Flight Facility to fly unmanned aerial systems and scientists to communicate with their payloads. In addition to serving the scientific community, the technology also could be used by the Defense Department, universities, and private industry.

Chapter Six

The Finale Event:

Scenes from the FY14 IRAD Poster Session

The IRAD year culminated with the annual "IRAD Poster Session," which showcased the work of nearly 100 principal investigators and attracted hundreds of visitors who praised the event's high-caliber content. This chapter tells the story in photos.

Hundreds of Goddard employees attended the FY14 IRAD Poster Session to learn more about the technologies that their colleagues are developing for a variety of spaceflight applications.

Visitors were greeted at the entrance of the Building 8 auditorium with this poster depicting not only the event's theme, but also three of Goddard's innovators, Matt McGill, Beth Paquette, and Gary Crum.

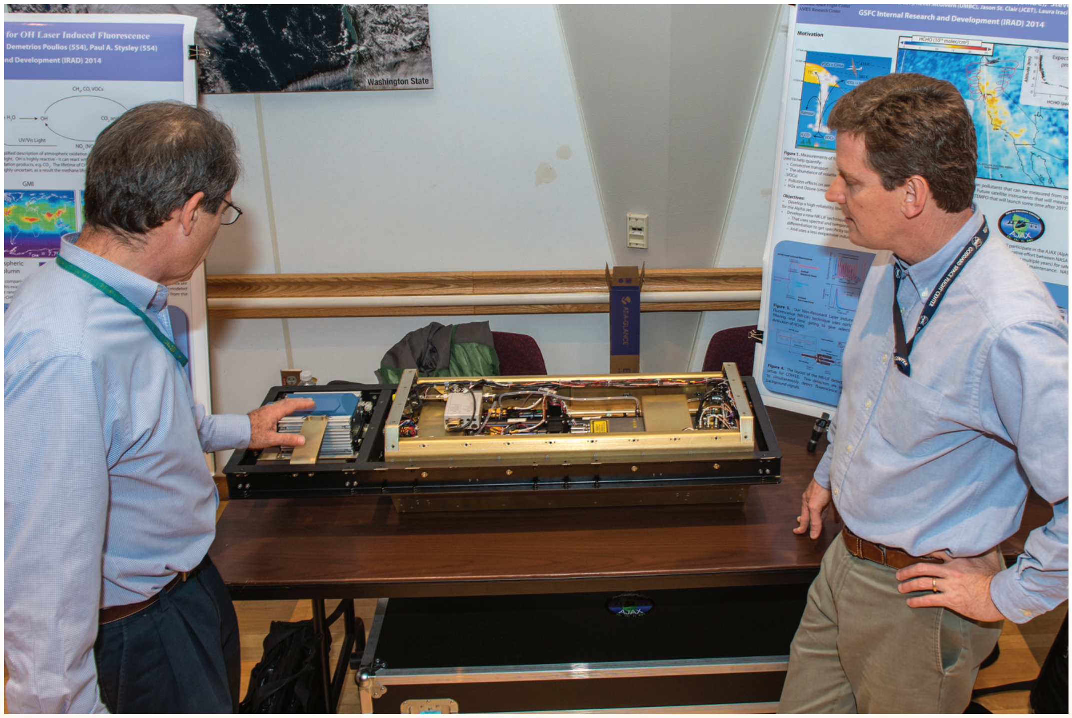
Principal Investigator Harvey Moseley talks with his colleague, Mary Li.

Goddard Chief Technologist Peter Hughes (right) addresses the assembled crowd prior to announcing the year's IRAD Innovator of the Year. Piers Sellers, Code 600 deputy director, and Colleen Hartman, Goddard deputy director for science, operations, and program performance, look on.

Elizabeth Timmons visits Romae Young, who staffed the NASA TechPort exhibit. TechPort is a new Web site for exploring NASA-developed technologies.

The Office of the Chief Technologist selected Matt McGill (left) and his team as the FY14 IRAD Innovators of the Year. Team members include (from left to right): Stan Scott, Andrew Kupchok, and John Yorks.

Goddard Deputy Director for Science, Operations, and Program Performance Colleen Hartman chats with Principal Investigator Joe Nuth about the tower test facility he and his team are developing to test a potential sample-collection technology.



Goddard scientist Gerry Heymsfield (left) talks with Principal Investigator Tom Hanisco about Hanisco's formaldehyde fluorescence instrument.

Goddard Deputy Director for Science and Technology Orlando Figueroa stopped by the poster session to talk with former colleagues. He is shown here with Associate Director for Research and Development, Sciences and Exploration Directorate Azita Valinia.

Chapter Seven

The Good-Humored Expert:

A Tribute to Wayne R. Powell (1941-2014)

In FY14, Goddard's technology community mourned the unexpected passing of Wayne Powell, a long-time NASA employee known for his good humor and willingness to help and mentor colleagues.

Powell had collapsed at his Pocomoke City, Maryland, home just one day after being released from a rehabilitation hospital where he had been treated for injuries sustained in a serious car accident. Paramedics could not revive him.

"We were all looking forward to Wayne's recovery and his return to work," said Goddard Chief Technologist Peter Hughes, who had worked with Powell for many years through the Goddard Technology Federation of which Powell had been a long-time member. "Always cheerful, Wayne was ready to share his considerable expertise in suborbital platforms and range services whenever asked."

Born in 1941 in Salisbury, Maryland, Powell earned a B.S. degree in mechanical engineering and a Master's in electrical engineering from Old Dominion University in Norfolk, Virginia, where he taught until joining Computer Sciences Corporation at Wallops Island in 1970. Six years later, he joined NASA, supporting rocket launches.

"His vast technical knowledge helped us position the Wallops Flight Facility as the go-to venue for launch services, suborbital communications, and other capabilities that continue to enable important scientific investigations," Hughes added. "Words simply do not convey my sadness and sense of tremendous loss at Wayne's untimely passing."

Although Wayne had significant technical expertise, "he was quick to ask tough questions and was humble enough to seek inputs from others," recalled Steve Nelson, assistant director of the Applied Engineering and Technology Directorate at Wallops. "He found humor in everyday situations, and had a booming, infectious laugh that brightened your day. I will miss him."

His wife, a sister, several nieces and nephews, and a pet cat survive him.